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MEMO

To:	Rick L. Bousquet, Liollio
From:	Dorothy S. Krotzer, BCA
Date:	5/5/09
Subject:	Fort Sumter National Monument

The following is a summary of immediate observations and recommended "next steps" related to the brick masonry of Fort Sumter National Monument, as identified during my site visit and meeting with the project team on 4/21/09-4/23/09. Members of the "project team" include the NPS staff of Fort Sumter National Monument, Liollio Architecture and BCA. The intention of this memo is to provide a prioritized course of action for the maintenance of the brick masonry of the fort, including the development of an appropriate restoration mortar for the site. The observations listed below will also inform BCA's proposal for additional consulting services.

Immediate Observations

Brick (Images 1-7)

1. The bricks used to construct Fort Sumter are handmade "Carolina Grey" bricks, reportedly manufactured locally at various plantations in the Charleston area, suggested a range of brick type and quality. They contain visually apparent inclusions or impurities that give them their characteristic mottled appearance. In addition, the inclusions are weathering at a slower rate than the matrix of the brick, causing the inclusions to protrude from the face of the weathered brick. This is a ubiquitous condition. The inclusions have not been identified with any certainly put are believed to be phosphorous-containing. Given that the bricks were handmade, much of the brick may have been low-fired and thus more susceptible to weathering.
2. Currently, the brick exhibits a wide range of conditions, most pronounced when comparing the interior and the exterior surfaces. The more protected interior brick is essentially intact, with the exception of a few areas where the brick was damaged in the Civil War or in areas where it is exposed to exterior conditions (i.e. adjacent to window openings, water run-off or rising damp). The historic (possibly original) mortar is fairly intact in these interior surfaces as well, particularly inside the casemates. The exterior brick walls are in far worse condition, with what appears to be extensive alveolar damage resulting from wind erosion. The majority of the brick has lost its fire skin, a condition that exacerbates the deterioration of the more vulnerable brick interior. In several locations, entire bricks have been lost from the outer wythe of the exterior wall. The worst areas in terms of overall brick damage were located on the east, southwest and west walls. The east wall in particular is experiencing active deterioration that is visible to the eye. Formation of salt crystals on the face of the brick are generating new, small spalls and causing active loss of material.
3. Previous testing was performed on brick units removed from Fort Sumter, although the exact location of the brick is unknown. The testing showed while the brick typically meets the ASTM requirement for compressive strength, it exceeds the maximum requirement for water absorption.

4. Environmental conditions that could be impacting the exterior brick wall include: wind, wave action/impact, cycles of water saturation and drying in tidal areas, salts and wind-driven sand.

Mortar (Images 8-12)

1. Numerous campaigns of pointing mortar were observed at Fort Sumter, particularly on the exterior walls. This is a result of the harsh environment and subsequent accelerated erosion of mortar necessitating frequent re-pointing over the past several decades.
2. Although the original and early historic mortars used to construct the fort have not yet been identified, it is highly likely that they were based on natural cement, probably the domestically produced Rosendale. This is based on archival documentation of the fort's construction, as well as recent findings at other similar coastal fortifications dating from the same time period.
3. With some exceptions, the majority of the mortar in the exterior and interior walls seems to be performing adequately. There are few areas of completely open joints or severely deteriorated, friable mortar. However, there are so many pointing campaigns, it is hard to make a general comment about mortar condition or performance.
4. Re-pointing campaigns from the past 10-30 years, implemented by the NPS, have been predominantly a Type K lime-cement hybrid mortar. This is the "weakest" mortar for which there is an ASTM standard. It is recognized as a mortar of low compressive strength and a high rate of water vapor transmission, although these properties are dependent on the actual proportion of ingredients as well as the sand used for the mortar. Other modern re-pointing campaigns include mixes based Rosendale cement recently installed by the NPS and mortars installed earlier in the 20th century based predominantly on Portland cement, some of which have negatively impacted adjacent brickwork.
5. It is difficult to assess the impact of the various pointing mortars on the brick. This is due to the fact that the brick is so deteriorated, identifying areas of new damage such as spalls or cracks can be very challenging. The only location where new damage was observed was the east elevation of the exterior scarp wall. This wall receives the greatest amount of wave action (from passing ships) and is presumably saturated with salt water on a regular basis, resulting in cycles of wet-dry conditions and salt crystallization that can damage brick.

Interpretive Concerns

1. The principal period of interpretation for Fort Sumter relates to the Civil War, although the site served as a defense fortification through World War II. Therefore, the physical portions of the fort that existed at the time of the Civil War are currently seen as the most significant.
2. The fort, as it exists today, is an amalgamation of numerous construction campaigns, making the return of its appearance to a specific point in time challenging. The wide array of modern (20th and 21st century) re-pointing campaigns is visually distracting and may not be representative of the fort's historic appearance. However, maintaining some degree of variation in the fort's masonry may be considered desirable from an interpretation perspective, as any variation in the fort's construction could represent an interpretive opportunity such as a discussion of the construction history of the fort or the impact of the war and subsequent rebuilding campaigns. A balance needs to be struck between respecting the fort's evolutionary complex construction history and creating a somewhat cohesive overall appearance.

Next Steps

Task 1. Finalize Scope of Work for Laboratory Testing & Analysis

1. Project team to finalize the scope of work for the testing and analysis of both bricks and mortar. BCA will make any necessary changes to the scope of work to reflect changes discussed during the site visit, including the addition of brick testing to the scope of work. BCA will also provide specific direction on brick sampling locations and quantities to the NPS.
2. The goal of the lab testing and analysis will be to document the composition and physical characteristics of the historic mortar materials used at the fort, including both brick and mortar. Physical characteristics include: color and overall appearance, water absorption (capillary uptake and water vapor transmission), compressive strength and flexural strength. Mechanisms of deterioration, such as salt damage, will also be examined.
3. The information generated as part of this lab analysis phase will be integrated into the HSR and used to guide the development of an appropriate restoration mortar for the site. An "appropriate" mortar is defined as one that will weather sacrificially to the brick but at a reasonable rate to reduce life cycle costs. It is possible that the mortar used historically at the fort is no longer appropriate for the brick in its current condition, but this would have to be established through the laboratory testing.
4. Project team should discuss the possibility of adding the testing of restoration mortars to the scope of work. Testing restoration mortars, namely the Type K lime-cement mortar used by the NPS for the past 20-30 years and a natural cement-based mortar using Rosendale natural cement, may prove useful in establishing the physical characteristics of viable restoration mortars and comparing them to the data generated for the existing brick.

Task 2. Review Results of Laboratory Testing & Analysis

1. Project team will review results of the lab analysis. BCA will provide relevant interpretation and application to the site, as necessary.
2. BCA will conduct secondary research to supplement understanding of the lab data, and to develop the best approach for the long-term maintenance of the brick masonry. For this research, BCA will utilize its in-house technical expertise, namely that of Dr. George Wheeler.
3. Results of lab testing and research will be integrated into the HSR and recommendations made for appropriate restoration mortars based on findings.

Task 3. Identify Areas of Additional Research

1. The project team will identify areas of additional research that are necessary to fully understand the deterioration of the brick masonry of the fort, but that cannot be completed as part of the HSR. Such additional research may include documentation of environmental factors affecting the brick masonry (such as wind and wave action) and establishing the rate of the brick deterioration.
2. Recommendations for additional research will be included in the HSR, with the expectation that the research be executed at a later date and as a separate project. The additional research could take many forms. For instance, it could be implemented as a discrete NPS-funded project, or as grant-funded project, or as graduate-level research project in conjunction with an academic program focused on materials science or historic preservation.


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Images 1 and 2. Fort Sumter, April 2009. The first tier casemates contain areas of relatively intact interior brickwork and mortar. These brick represent the original appearance and condition of the Carolina Grey bricks.

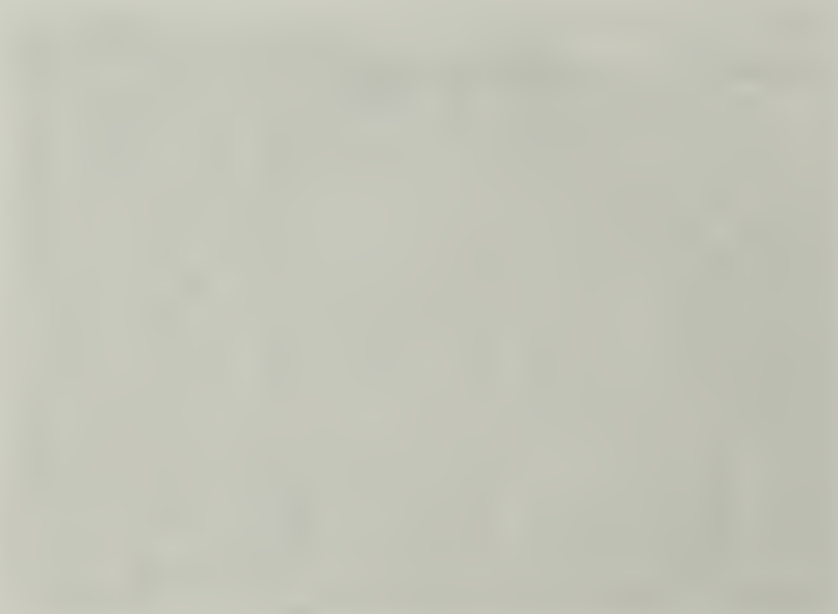

Image 3. Fort Sumter, April 2009. North elevation, showing example of modern re-pointing and condition of brick. Note more deteriorated band of brick at bottom center.

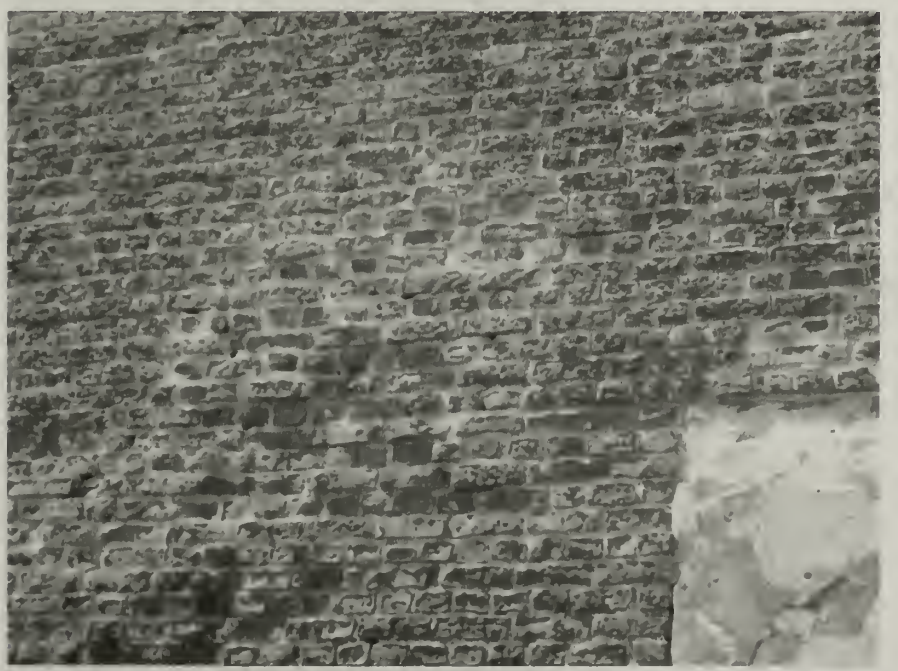

Image 4. Fort Sumter, April 2009. East elevation, detail of brick condition. This wall receives more wave impact and saturation with sea water than others and the brick is subsequently more deteriorated.

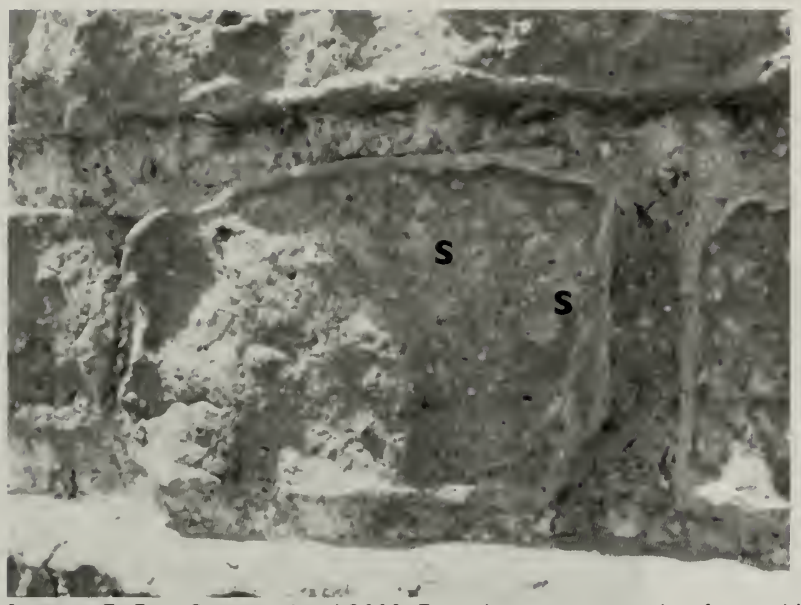

Image 5. Fort Sumter, April 2009. East elevation, example of typical brick deterioration on this elevation. Note presence of white salt crystals on surface (S) and subsequent small brick spalls, as well as the difference in rate of deterioration of brick fire skin versus interior.

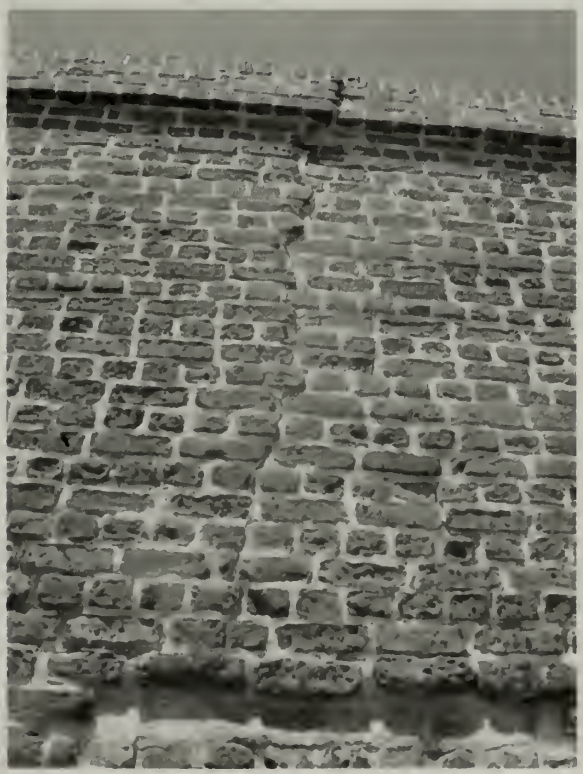

Image 6. Fort Sumter, April 2009. Southwest elevation, area of structural crack.

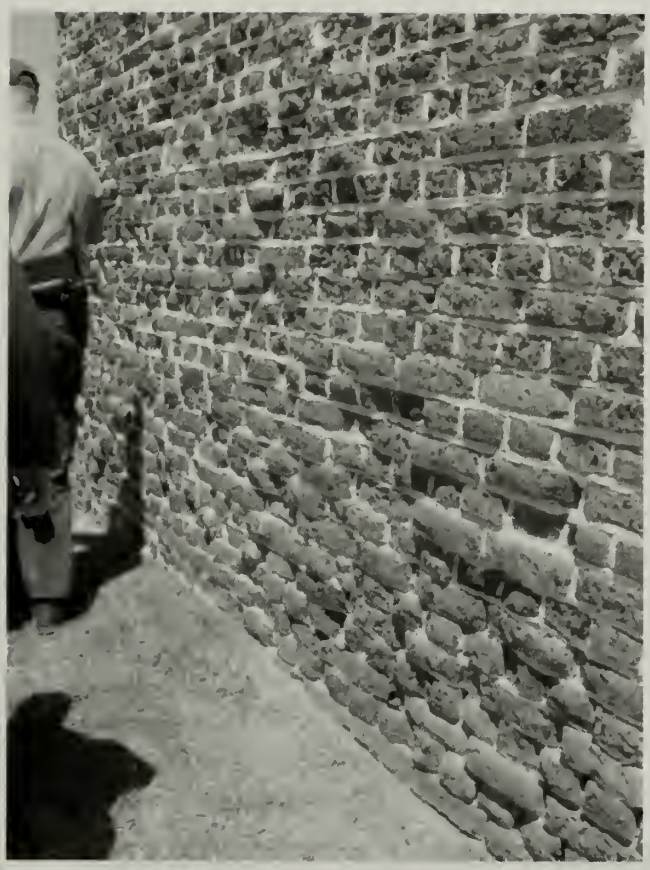

Image 7. Fort Sumter, April 2009. West/Northwest elevation, area of distinct alveolar (wind-driven) erosion.

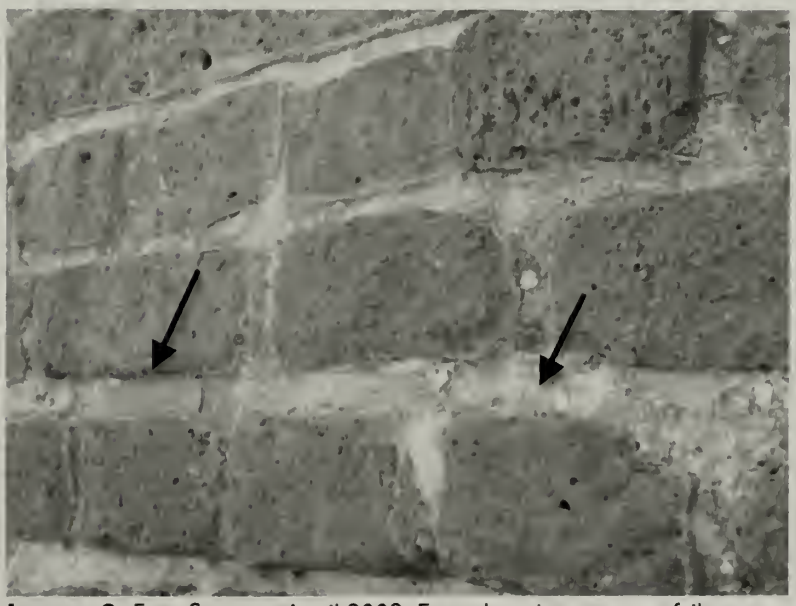

Image 8. Fort Sumter, April 2009. East elevation, mortar failure.

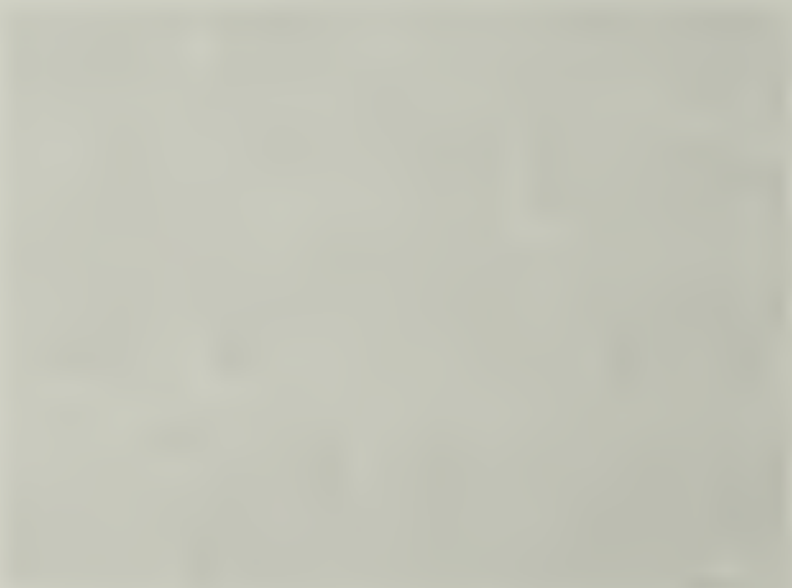

Image 9. Fort Sumter, April 2009. East elevation, condition of mortar (presumably historic) at base of wall with constant exposure to water, particularly at high tide.

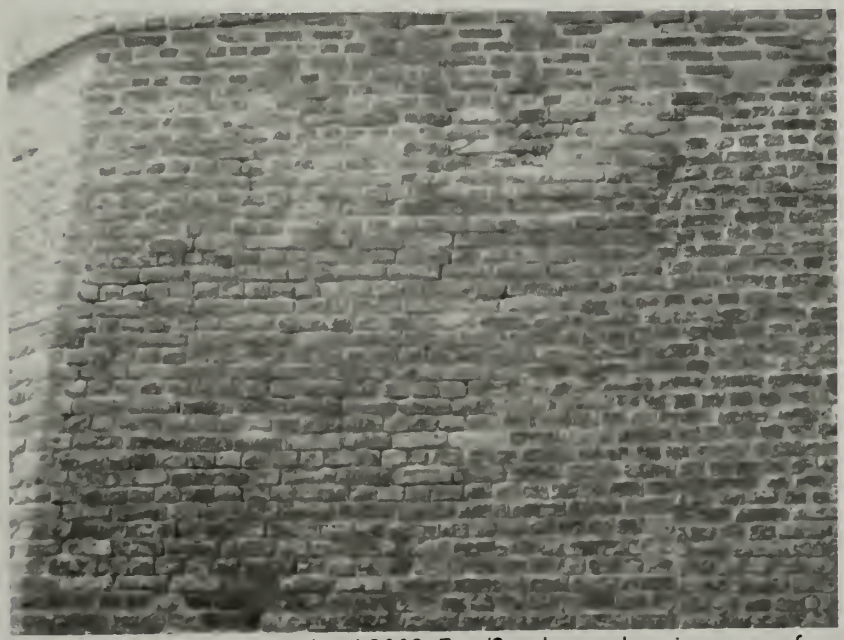

Image 10. Fort Sumter, April 2009. East/Southeast elevation, area of open mortar joints.

Image 11. Fort Sumter, April 2009. Exterior scarp wall, an area of prior re-pointing campaign based predominantly on Portland cement. Note condition of surrounding brick, it has weathered at a more advanced rate then the mortar, producing a characteristic "honeycomb" effect.

Image 12. Fort Sumter, April 2009. Southeast Elevation, area re-pointed in 2008 using Rosendale natural cement gauged with hydrated lime. The streaking on the wall is most likely due to the lime component of the mortar washing out of the mortar prior to achieving full carbonation.